BRIDGING NUCLEAR SAFETY, SECURITY AND SAFEGUARDS AT GEOLOGICAL DISPOSAL OF HIGH LEVEL RADIOACTIVE WASTE AND SPENT NUCLEAR FUEL

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Abstract. In order to consider geological disposal of high-level radioactive waste and spent nuclear fuel in all its complexity, related nuclear safety, security and safeguards issues have to be taken into account. By identifying both synergies in overlapping methods or techniques and differences in the requirements with respect to safety, security and safeguards, advantage of inherent synergies and conflicting requirements can be taken at the same time. While there is a general understanding of the potential benefits of the 3S concept, neither the interfaces and synergies between safety, security and safeguards nor their practical implementation are yet fully understood. This paper discusses the role and importance of safety, security and safeguards regarding the geological disposal of high-level radioactive waste and spent fuel.

Key Words: Safety; security; safeguards; 3S

1. Introduction

The use of the terms ‘nuclear safety’, ‘nuclear security’ and ‘nuclear safeguards’ is often not sharply delimited from each other, though definitions for each of these issues exist. According to IAEA definitions, ‘nuclear safety’ refers to “*[t]he achievement of proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of workers, the public and the environment from undue radiation hazards*” [1], and therefore stands for the safe operation of nuclear installations.

‘Nuclear security’ implies “*[t]he prevention and detection of, and response to, theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear material, other radioactive substances or their associated facilities*” [1] and is aimed at the physical protection of nuclear installations.

‘Nuclear safeguards’ are “*designed to ensure that special fissionable and other materials, services, equipment, facilities, and information made available by the Agency or at its request or under its supervision or control are not used in such a way as to further any military purpose*” [2] or, in short, to ensure the peaceful use of nuclear material.

The interaction or intersections of the three components depend on the context, and the significance of each of the components may vary for different types of nuclear installations.

In order to consider geological disposal of high-level radioactive waste and spent nuclear fuel in its full complexity, all related nuclear safety, security and safeguards issues must be taken into account. While safety can benefit from some provisions regarding safeguards and physical protection (security), it may also be contravened by others. Some techniques for monitoring geological repositories, such as environmental sampling, could provide relevant data for safety, security and safeguards. Other techniques, such as geophysical measurements for safeguards verification, are to be implemented in a way that does not infringe long-term safety requirements. Therefore, identifying both synergies in overlapping methods or techniques or with respect to their future development as well as differences in the requirements with respect to safety, security and safeguards may help to take advantage of inherent synergies and conflicting requirements at the same time.

The need of integrating the three ‘S’s’, also referred to as the ‘3S concept’, to the extent possible throughout all the stages of the nuclear installations’ life cycle, was recognized by the IAEA in 2008 [3,4] and at the same time, the G8 countries declared to support the 3S concept [5,6] . Since then, a number of papers discussed the benefits of considering a 3S approach [e.g., 7-9] in designing and operating nuclear facilities, but only a few addressed the issue of applying 3S to geological disposal of high-level radioactive waste and spent nuclear fuel [10-12].

While there is a general understanding of the potential benefits of the 3S concept, neither the interfaces and synergies between safety, security and safeguards nor their practical implementation are fully understood to date. This also applies to the geological disposal of high-level radioactive waste and spent nuclear fuel. Numerous legislations, regulations and other documents have emphasized that safety is the primary requisite in all life cycle stages of geological repositories. But what is the significance of security and safeguards with respect to geological disposal?

2. Role and importance of safety, security and safeguards regarding the geological disposal of high-level radioactive waste and spent nuclear fuel

2.1.Legal and organizational framework

Nuclear safety, security and safeguards legislations are laid down in a series of national and international agreements, conventions and regulations [13]. With reference to the 3S concept, the IAEA noted the need for nuclear legislation that reflects the interrelations between safety, security and safeguards in a comprehensive and synergetic manner [14]. Accordingly, any new or revised nuclear legislation on geological disposal of high-level radioactive waste and spent nuclear fuel should also take 3S conflicts and interfaces into account.

Safety and security are mainly based on an appropriate national legal and organizational framework, including national regulatory oversight of safety and national law enforcement in case of security threats. Safeguards, however, represents an international legal commitment, determined by safeguards agreements and additional protocols between States and the IAEA [15]. States under safeguards verification by the IAEA usually have a national or regional Safeguards Regulatory Authority (SRA) in place that acts as interface between the State and the IAEA. Some States, such as Finland and Japan, have established national regulatory bodies that cover safety, security and safeguards issues of their nuclear installations and programmes, including geological disposal, in a single organization [10].

2.2.Material concerned

Safe geological disposal requires a stable geological formation to provide for the long term containment of radionuclides and their isolation from the biosphere. Safety therefore addresses all types of radionuclides, in particular the long-lived ones (with half-life periods in the order of up to 10^7 years), i.e. actinides and long-lived fission and activation products. Security considers nuclear material and other radioactive material [1], and safeguards are principally applied to all source (uranium, thorium) or special fissionable material containing uranium or plutonium [2]. The lowest common denominator of a 3S control of nuclear material in high-level waste and spent nuclear fuel would therefore include uranium, plutonium and thorium.

2.3.Timelines

The safety case and safety assessment for geological disposal facilities consider the three life cycle stages, i.e. the pre-operational period, the operational period and the post-closure period, spanning over periods in the order of thousands of years and potentially longer (i.e. up to hundreds of thousands of years) [16]. Security measures do address the three life cycle stages as well, with a focus on the pre-operational and operational periods, although a generally care and maintenance free post-closure phase is stipulated in the regulations in various countries. The timeline for safeguards activities is bound by the duration of the safeguards agreements and, in the end, will be applied as long as the Nuclear Non-proliferation Treaty (NPT) remains in force.

A 3S assessment should thus be based on the longest timeline of the single 'S'-components, while the role and importance of each of the three 'S's' would vary or decrease over time. If a '3S case' was to be prepared instead of the safety (1S) case, the long-term post-closure period would mainly be assessed from the safety perspective.

2.4.Control measures

Safety, security and safeguards activities include similar or complementary measures for documenting, measuring and monitoring the inventory of radionuclides, in particular with regard to uranium, plutonium and thorium. In order to avoid redundancy or duplication of work and equipment, a material control and accountancy system should include practices and procedures, as well as techniques for measurement, sealing and surveillance that fulfil the requirements as to safety, security and safeguards to the extent possible.

2.5.Facility design

The IAEA generally considers safety, security and safeguards as essential elements in all life cycle stages of nuclear facilities. In this context, the IAEA has issued a guidance document [17] aimed at informing stakeholders how to design facilities for nuclear waste management by early consideration of safeguards in the planning stage so that provisions can be better integrated with other design requirements as to safety and security.

This approach, also referred to as 'safeguards by design' (SBD) should be more closely interlocked with the 3S concept. 'Safety, security, safeguards by design' (3SBD), as generally proposed by [18,19], can help to reduce efforts and costs related to nuclear waste management and disposal.

3. Findings

Safety, security and safeguards aspects regarding the geological disposal of high-level radioactive waste and spent fuel should be addressed and managed in a coordinated, complementary approach. Further R&D will be needed to identify methods and technologies (a '3S toolbox') that would be best suited for the holistic consideration of safety, security and safeguards provisions. By early consideration of conflicting requirements as to safety, security and safeguards, their impacts on all three life cycle stages of geological disposal can be minimized. The 3SBD toolbox should include methods and technologies for material accountancy, nuclear measurements, containment and surveillance, environmental monitoring, continuity of knowledge, as well as design implications to the benefit of all safety, security and safeguards at geological disposal.

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